Dichotic Word Recognition of Young Adults in Noise

A Senior Honors Thesis

Presented in Partial Fulfillment of the Requirements for graduation with distinction in Speech and Hearing Sciences in the undergraduate colleges of The Ohio State University

by

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ABSTRACT

Dichotic word recognition (DWR) was measured in both quiet and noise among young adults with normal hearing. In the noise condition, performance was reduced until it equaled that of older adults with hearing loss (e.g., Roup et al., 2006). Differences in performance between ears [i.e., the right ear advantage (REA)] were compared between both dichotic conditions (quiet and noise). Despite the introduction of noise and the subsequent increased difficulty of the task, the mean REA in the noise condition remained small. Further, no significant differences were exhibited between mean REAs in quiet and noise. Mean REAs from the noise condition were then compared to previously collected dichotic word recognition data from older adults with sensorineural hearing loss. Overall performance was comparable between the two groups; however, the young adults exhibited much smaller mean REAs. The fact that the REAs of the young adult subjects were not significant in the presence of increased difficulty (e.g., noise) lends support to the suggested hypothesis that the disproportionately large REAs exhibited by older adults reflect changes in auditory processing rather than the effects of peripheral hearing loss.

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Chapter 1

INTRODUCTION AND LITERATURE REVIEW

Dichotic listening consists of presenting two competing speech stimuli simultaneously to a subject and then asking that subject to recall both. As the stimuli are presented to both ears simultaneously, competition is created in the processing of those stimuli. In early research conducted using the dichotic paradigm, the right ear seemed to have an advantage over the left ear, meaning more stimuli were successfully recalled from the right ear than from the left. Further research concluded that this advantage was due to the way in which the auditory pathways connect to the brain. Through the use of electrophysiological measurements, contralateral auditory pathways have been established as stronger than ipsilateral pathways (Kimura, 1961). The right ear is connected contralaterally to the left hemisphere, where language is processed for the majority of people. Also, Kimura's early work with dichotic listening demonstrated that the ipsilateral pathways are suppressed during dichotic listening (Kimura, 1961). As language is processed in the left hemisphere, one would expect a subject to more successfully recall dichotic speech stimuli that were presented to the right ear; the ipsilateral pathways are suppressed, forcing the stimuli to travel using the stronger contralateral pathways. The speech stimuli presented to the left ear travel contralaterally to the right hemisphere, and then must cross to the left hemisphere to be processed. The signal crosses from the right to left hemisphere by use of the corpus callosum. Energy is thought to be lost in the crossing of hemispheres, causing the left ear to be disadvantaged in dichotic situations (Jerger, Alford, Lew, Rivera & Chmiel, 1995). Through the extensive research conducted in the dichotic testing field, a right ear advantage in dichotic situations has indeed been observed in a large majority of test subjects.

Early Dichotic Research

The history of dichotic research begins in 1954 with Broadbent's work in recreating the auditory environment of air traffic controllers. As air traffic controllers often receive more than one message at a time, comprehension was often compromised due to the competition of the multiple messages. When Broadbent introduced competing messages simultaneously to both ears, he found that, "All correct responses to binaural lists were written down in such an order that all digits presented to one ear were written down before any of the other ear" (Broadbent, p. 194). Broadbent concluded that "The sound on one ear produces a response before that on the other ear" (p. 195). Although Broadbent did not report that there was a right ear advantage due to strong contralateral auditory pathways and suppression of ipsilateral pathways, he was able to discover a pattern in the recall order of dichotic stimuli. Although the report of a right ear advantage in dichotic situations came later, Broadbent's work was critical in the early development of dichotic research.

Language Lateralization and the Right Ear Advantage

There is an extensive history of research regarding the discrepancy in recall success rates for the right and left ear in dichotic situations. Kimura conducted research in the areas of language lateralization and dichotic listening using hospital patients who had temporal lobe lesions. She had the subjects perform a dichotic digit task, which consists of simultaneously presenting one monosyllabic digit to each ear and then asking the listener to recall the presented digits. Kimura then compared the performance of those with lesions of the left temporal lobe to those with lesions of the right temporal lobe. The subjects with damage to the left temporal lobe performed worse than subjects with right lobe damage. The mean percentage score of correct responses for those with left temporal damage was 84 percent, while the score for those with damage to the right temporal lobe was 91 percent (Kimura, 1967). Although the difference between groups was small, it lends support to the hypothesis that the left hemisphere was responsible for language perception, as damage to the left hemisphere resulted in poorer performance in this language based task.

Through her research with these subjects, Kimura also noted that more digits were correctly reported from the right ear than from the left ear, regardless of the site of the lesion. This right ear advantage was also found in patients without damage to the temporal lobe. As previously discussed, ipsilateral pathways are suppressed during dichotic situations, forcing the use of the contralateral pathways. Therefore, the stimuli that were presented to the right ear would travel contralaterally to the left hemisphere and the stimuli presented to the left ear would travel contralaterally to the right hemisphere. Therefore, the fact that digit stimuli were more accurately reported from the right ear than from the left ear lends support to the proposed hypothesis that language is processed in the left hemisphere. The higher recall rate for the right ear stimuli is directly related to the strong contralateral connection between the right ear and left hemisphere. The left ear has the same strength contralateral connection with the right hemisphere, but this connection does not produce the same results. This suggests that the left hemisphere is dominant for language.

The development of sodium amytal procedures allowed researchers to more accurately determine language lateralization. A sodium amytal procedure, commonly known as the Wada test, was developed by Canadian neuropsychologist Juhn A. Wada and consists of temporally anesthetizing one side of the brain in order to establish cerebral dominance. Sodium amytal is injected into either the left or right carotid artery, effectively shutting down the functions of one hemisphere. When the left hemisphere is anesthetized, the subject exhibits reduced or nonexistent language skills but is still able to sing. This test confirms the idea of a lateralized brain, the left hemisphere typically being responsible for language and the right for nonverbal information.

Through the sodium amytal technique, it was proven that while the large majority of people process language in their left hemisphere, a small group do exhibit right hemisphere language control. Kimura used this small group of people with right hemisphere language lateralization to see if the ear superiority switched with right hemisphere language lateralization. A left-ear advantage was indeed exhibited by those with right hemisphere language processing (Kimura, 1967). In general, research involving dichotic situations is conducted with people who process language in the same hemisphere, and this lateralization is generally determined by handedness.

<u>Nonverbal Stimuli and the Left Ear Advantage</u>

Thus far, all described research has been conducted with verbal stimuli which results in a right ear advantage due to the huge majority of people with left hemisphere language lateralization. However, when nonverbal stimuli are used (e.g., tones) the ear advantage is switched (Kimura, 1967). Kimura used melodies in a dichotic task involving a multiple choice recognition technique. The musical stimuli were presented dichotically, and then the subject was asked to pick out the two melodies he/she heard from a group of four total melodies. The subjects were better able to identify the nonverbal stimuli presented to their left ear than their right ear. These same subjects were then presented the dichotic digits test, in which they more accurately reported stimuli presented to their left ear. For the dichotic melodies task, the 20 normal subjects had an average left ear advantage of 12%. However, in the dichotic digits paradigm those same subjects exhibited a 4% right ear advantage. This validates the concept of a lateralized brain; verbal stimuli are processed in the left hemisphere and nonverbal are processed in the right.

Handedness and Ear Advantage

As a huge majority, people process language in their left hemisphere. Sodium amytal procedures are no longer used to determine language lateralization; instead researchers rely on handedness as a measure of cerebral dominance. Specifically, when measuring dichotic speech recognition, researchers restrict testing to right-handed subjects because they presumably process language in their left hemispheres. While this does not absolutely guarantee the elimination of any subjects who process language in the right hemisphere, it makes it highly improbable. In a study using the sodium amytal technique, researchers Branch, Milner, and Rasmussen (1964) found that 90% of right handed people had language lateralized in the left hemisphere.

Therefore, by only using right handed subjects one can generally assume that those subjects have left hemisphere language processing. While one would assume that left handed people would show an equally large percentage of right hemisphere language dominance, 60% of left-handed subjects exhibited left hemisphere language processing (Branch, Milner, & Rasmussen, 1964). This is a result of left handed people being more ambidextrous than right-handed people; this ambidexterity is caused by a society that caters to the right handed majority. This means that left handed people may have more connections between their hemispheres, resulting in less lateralization.

In Wilson and Leigh's (1996) study of dichotic performance of left and right handed listeners, they found that both right and left handed subjects exhibited mean right ear advantages. However, the magnitude of the right ear advantage of right handed subjects was much larger than the advantage of the left handed subjects. On average, the right handed subjects correctly identified 72.8% of materials presented to their right ear, and 56.5% of materials presented to their left ear; this resulted in a 16.3% difference in performance between ears. In comparison, the left handed subjects correctly reported 62.9% of materials presented to their right ear and 61.1% of materials presented to their left ear, resulting in a difference of only 1.8% between ears (Wilson & Leigh, 1996). This shows that left handed people generally exhibit more variability in dichotic situations. For this reason, dichotic research is often conducted only with right handed subjects in order to ensure more reliability and less variability of results.

Response Condition and the Ear Advantage

Throughout the history of dichotic testing, a variety of response conditions have been used. The two most prominent are free recall and directed attention recall. In free recall situations, the subject is instructed to recall the stimuli from both ears, in any order. For the majority of people, a free recall situation results in a right ear advantage, due to previously discussed left hemisphere lateralization of language. In directed recall, the listener is instructed to attend to only one designated ear, and ignore the stimuli presented to the other. This ear cue is given before the stimuli are presented to the listener. When the listener is instructed to attend to the right ear, a large right ear advantage is seen. The directed recall right ear advantage is typically larger than the free recall right ear advantage, a result of the listener being able to ignore the stimuli presented to the non-cued ear and give full focus to the right ear stimuli (Strouse, Wilson, & Brush, 2000). If the subject is asked to attend to the left-ear, a left-ear advantage is generally exhibited; however its magnitude is less than the right ear advantage of directed right ear recall (Strouse et al., 2000).

Another response option within directed recall is post-cued directed recall. As opposed to the pre-cued directed recall situations discussed above, the subject in this task does not know which ear will be cued until after the stimuli are presented. The subject listens to all the stimuli, and afterwards is asked to recall the stimuli from a specific ear. This response condition is obviously much more difficult, and is more influenced by memory and cognitive abilities. Also, the right ear advantages exhibited in post-cued directed recall are typically inflated, with the suggested cause being the increased difficulty of the task (Strouse et al., 2000). The inflated right ear advantages and poor overall performances exhibited in post-cued recall conditions have caused many researches to choose other response conditions, such as free recall or pre-cued directed recall.

Stimuli

There are multiple stimulus options that can be used in dichotic speech recognition. These options include digits, words, sentences, and consonant vowels (CVs). The most employed form is digits. The appeal of digits is that they are fairly immune to the effects of mild-to-moderate sensorineural hearing loss, and digits have high inter-test reliability (Strouse et al., 2000). However, digits are a closed-set task, which results in high familiarity and the possibility of accurate guessing on behalf of the listener. In dichotic research conducted by Roup, Wiley, and Wilson (2006), monosyllabic words were used instead of digits for four explicit reasons. First, monosyllabic words limit syntactical cues. Second, the available standardized recorded monosyllabic word lists are easily accessible and in extensive use. Third, the available normative database for monaural word-recognition is quite extensive. It includes listeners with both normal and compromised hearing, from all age groups. The last reason for monosyllabic word use is that words are not a closed set stimulus, whereas digits are. While Roup et al. (2006) chose to use monosyllabic words, the majority of testing is still conducted with digits. In regards to the other forms of stimuli, many researchers believe that sentences provide too many contextual clues to be useful in dichotic testing and that CV stimuli are too difficult. Another factor to consider when choosing stimuli is that the type of stimuli used does have an effect on the magnitude of the ear advantage, as the advantage is dependent upon the difficulty of the task (Wilson & Jaffe, 1996). The more difficult the task, the greater the right ear advantage. The right ear advantage is typically smallest when digits are used, and largest when CVs are used. Dichotic words or sentences typically result in a right ear advantage that falls in between that of digits and CVs.

Age Effects on the Ear Advantage

Once right-ear advantages in dichotic testing were established, many researchers questioned the variance in degree of this advantage. Through the work of more recent researchers a crucial component was discovered and consequently researched. This discovery is that older adults exhibit a much larger right ear advantage than younger adults.

In one study conducted by Bellis and Wilber (2001), dichotic performance and the magnitude of the right-ear advantage were studied over four age groups. The subjects were grouped into four age categories- ages 20-25, ages 35-40, ages 55-60, and ages 70-75. In general, the older groups had a poorer dichotic performance. In regards to ear advantage, all age groups exhibited a right ear advantage, although to varying degrees. While those ages 20-25 had an average right ear advantage of around 2%, the right ear advantage for those ages 70-75 was over 6%. Each progressive age group had a larger right ear advantage than the group before it.

Obviously, the overall performance gap, or percentage of correct answers, between younger and older adults is clearly related to the fact that most older adults have age-related hearing loss. Therefore, these normal hearing young adults should be expected to outperform the older adults. However, what can not be explained by the hearing loss is the rapidly declining ability of the older adults to recall stimuli presented in the left ear. The older adults had bilateral symmetric hearing losses, meaning that both ears were equally affected by the loss. Therefore, the overall performance of each ear should be equally compromised. A small right ear advantage in older adults would be expected, due to the previously discussed strength of contralateral pathways and suppression of ipsilateral pathways during dichotic listening. However, the right ear advantages in older adults were substantially larger. This has led many researchers to believe that this right ear advantage, or left ear disadvantage, is not related to a hearing loss; rather it is a direct result of an age-related auditory processing disorder. This means that in older adults the information being sent to the right hemisphere from the left ear is not being transferred to the left hemisphere as efficiently as it is in younger subjects.

The concept of age affecting auditory cross-hemisphere communication was studied by Jerger, Alford, Lew, Rivera and Chmiel (1995). They credited the decrease in efficiency of communication to age-related changes in the corpus callosum (Jerger et al., 1995). The corpus callosum consists of contralateral axon projections, meaning that it is responsible for communication between the two hemispheres. The corpus callosum has been proven to affect cross-hemisphere communication through the testing of subjects whose corpus callosums had been severed. Bellis and Wilber (2001) tested subjects with lesions of the corpus callosum and these subjects exhibited extremely poor performance in all tasks involving cross-hemisphere communication. Specifically, in dichotic auditory situations the lesion had reduced the ability to efficiently process competing stimuli presented to both ears (Bellis and Wilber, 2001). As discussed previously, dichotic listening involves the communication between the two hemispheres. In dichotic situations, stimuli presented to the right ear travel contralaterally to the left hemisphere and stimuli presented to the left ear travel contralaterally to the right hemisphere and then must cross to the left hemisphere. With a degraded corpus callosum, this transfer from right to left hemisphere would be disadvantaged. A degraded corpus callosum would result in an auditory processing disorder, which is the suggested reason behind the large right ear advantages seen in older adults.

Clinical Implications

It has been observed that some older adult hearing aid users prefer monaural amplification, despite having equitable hearing loss in both ears. Results of dichotic testing revealed substantial left-ear disadvantages among these listeners (Carter, Noe, & Wilson, 2001). According to Carter, Noe, and Wilson, these results “Indicate that listeners with an auditory-based deficit in dichotic listening may function better with a monaural hearing aid fitting” (p. 261). Word-recognition performance was tested in older adults with bilateral symmetric hearing loss in situations of both monaural right-ear and binaural amplification. Monaural right-ear amplification resulted in best performance. This is a result of the large left-ear deficits exhibited in older adults, with the suggested cause being an auditory processing disorder. According to the results of this case study, the amplification of the left-ear may be unnecessary, as the auditory processing disorder is causing the poor performance, not the hearing loss. While patients with bilateral symmetric loss are assumed to benefit from binaural amplification, the presence of an auditory processing disorder may dispute a binaural fitting.

Present Study:

The purpose of the present study is to investigate the effect of reduced dichotic word recognition (DWR) performance on the right ear advantage. This study will reduce the DWR performance of young adults with normal hearing until it is comparable to previously measured performance of older adults with hearing loss (e.g., Roup et al., 2006). The reduced DWR performance in young adults will be produced by introducing noise into the dichotic recognition task. The study will also measure the young subjects' DWR in quiet; these results will serve as baseline data. As previously discussed, older adults perform much poorer than young adults in dichotic situations and also exhibit much larger right ear advantages. The poor overall performance found in older adults is the result of an age-related hearing loss; the cause of the large right ear advantage is not completely understood. By equating the performance of young adults to that of older adults, the effect of the hearing loss will be removed. After establishing comparable performance, the magnitude of the right ear advantage will be compared to determine if the young adults exhibit similar large right ear advantages in the reduced DWR condition. Specifically, this study seeks to answer the following questions:

1) How will the introduction of noise, and subsequent reduced DWR performance, affect the right ear advantages of young adults listeners? When compared to the

right ear advantages in quiet, does the noise produce a marked change in the magnitude of ear advantage?

2) With comparable DWR performance, how do the right ear advantages of the young and older adults compare? When the young adults' performance is lowered to equal that of the older adults, do they exhibit the same large right ear advantage found in older adults? Or, does the right ear advantage of young adults remain small, despite the increased difficulty of the task?

If the right ear advantage remains small, despite the decrease in overall performance, this would lend support to the suggested hypothesis that the exaggerated size of the right ear advantage exhibited in older adults is due to an auditory processing disorder, not a hearing loss.

Chapter 2

METHODS

Subjects

The present study was conducted with 10 subjects, ages 20 to 25. Subjects were recruited from The Ohio State University student population. Within the group of 10, 5 subjects were male and 5 were female. All subjects were right-handed, which was confirmed through the use of the Edinburgh Handedness Inventory (Oldfield, 1971). Left-handed individuals exhibit more variability in dichotic listening, and were therefore excluded from the study. The Edinburgh Handedness Inventory consists of a simple and quick 10-item questionnaire resulting in a quantitative assessment of handedness (See Appendix A). Only those individuals who scored ≤ 20 were included in the study, ensuring that their right hand was measurably dominant.

All subjects had normal hearing, as defined by pure tone thresholds ≤ 20 dB HL at 250-8000 Hz. Bone conduction thresholds were within 10 dB of air conduction thresholds for 500-4000 Hz. Inclusion criteria for the present study included: (1) normal otoscopy (normal tympanic membrane, clear ear canal, and no structural abnormalities or history of otic disease); (2) tympanometry within normal limits (Roup, Wiley, Saffady, & Stoppenbach, 1998); and (3) no past or current illness that might affect their hearing and overall performance.

Materials

Two-hundred Northwestern University Auditory Test No.6 (NU-6) monosyllabic words from the Veterans Affairs compact disc (CD) were paired in order to create 100 dichotic word pairs (Speech Recognition and Identification Materials 2.0, Department of Veterans Affairs, 1998). Details describing how the word pairs were created are described in Roup et al. (2006). In order to create dichotic words in noise, each two-channel word pair was mixed with three separate types of speech spectrum noise at 10 different signal-to-noise (SN) ratios and recorded on CD. The three types of noise used were homophasic, antiphasic, and uncorrelated. The 10 SN ratios ranged from +3 dB to -15 dB, with each ratio increasing in increments of 2 dB.

Pilot Data

Pilot data was gathered on 2 subjects in order to determine if the type of speech spectrum noise influenced performance and to determine which SN ratio would produce the desired dichotic performance in noise of approximately 50%. The desired performance rate was based on the older adult data gathered from Roup et al. (2006) study. For both pilot subjects, dichotic word recognition (DWR) was measured in homophasic, antiphasic, and uncorrelated noise. The difference in overall performance between the three types of noise was not statistically significant. As the type of noise did not affect performance, only one noise type was used. Antiphasic noise was selected arbitrarily and all further testing was conducted with only this noise type. The two pilot subjects' DWR in noise was measured from a +3 dB SN ratio to +11 dB SN ratio. The subjects' did not exhibit the desired performance level until the SN ratio was increased to +11dB. Further testing was only conducted at +11dB SN ratio as the smaller SN ratios produced undesirable levels of performance. Four randomizations of the NU-6 dichotic words were generated, one in quiet and three at a +11 dB SN ratio.

Procedures

Dichotic word recognition was measured in quiet and in antiphasic noise (+11dB SN ratio) using the free recall response paradigm. In the free recall paradigm, the subject was instructed to recall the stimuli from both ears, in any order. In both the quiet and noise experimental conditions, 50 dichotic word pairs were presented to the listener at 50 dB HL. After being presented with a dichotic pair, the listener responded verbally and the responses were recorded as correct or incorrect. There was no feedback provided to the listener other than encouragement to perform the task. Also, the 4 list randomizations were counter-balanced across the 10 subjects in order to avoid list effects.

The stimuli were routed from a CD player to an audiometer (Grason Stadler, Model 61) and presented to the subject via insert earphones (E-A-RTONE 3A). All testing was conducted in a double-wall sound booth, and all experimental equipment was calibrated according the American National Standards Institute (ANSI, 1987, 2004).

Before the initial 50 dichotic pairs in quiet were presented, all subjects were familiarized with the dichotic listening situation through the use of a 10-item practice dichotic task. These practice item responses were not recorded.

Chapter 3

RESULTS

Table 1 presents the mean dichotic word recognition scores (in % correct) and standard deviations of each ear for the young adults in both quiet and noise conditions. The Roup et al. (2006) older adult data are presented in Table 1 for comparison. As can be seen in Table 1, the introduction of noise created a marked difference in performance between the quiet and noise conditions for the young adult subjects. Specifically, mean performance of the right ear (RE) in quiet was 86.4%, but in noise RE performance was lowered to 45.6%. Mean performance of the left ear (LE) in quiet was 83.6%, while the noise condition reduced performance to 41.2%. Therefore, the young adults in noise did exhibit the desired DWR performance level of 40-60% in each ear. The reduced performance level was created in order to produce comparable performance to the older adult data from Roup et al. The mean performance of the RE for older adults was 56.8% and the LE was 43%.

Figure 1 depicts individual dichotic word recognition (in percent correct) for each ear for the young adults in both conditions (quiet and noise). The X-axis represents the RE performance and the Y-axis represents the LE performance. Data points falling below the line signify a right ear advantage, and points above the line signify a left ear advantage. Figure 1 clearly shows the variability produced by the introduction of noise. The data points from the quiet condition are clustered close together, while the data points from the noise condition are more loosely clustered. The introduction of noise increased performance variability, meaning that the spread of the data values found in

Table 1. Means and standard deviations of dichotic word recognition performance for right and left ears, and combined across ears (overall) in both conditions (quiet and noise).

	Right Ear %	Left Ear %	Overall %
Young Adults quiet			
Mean	86.40	83.60	85.00
SD	6.24	6.92	6.57
Young Adults noise			
Mean	45.60	41.20	43.40
SD	9.74	9.48	9.63
Older Adults (Roup et al., 2006)			
Mean	56.80	43.00	49.90
SD	19.30	25.60	23.56

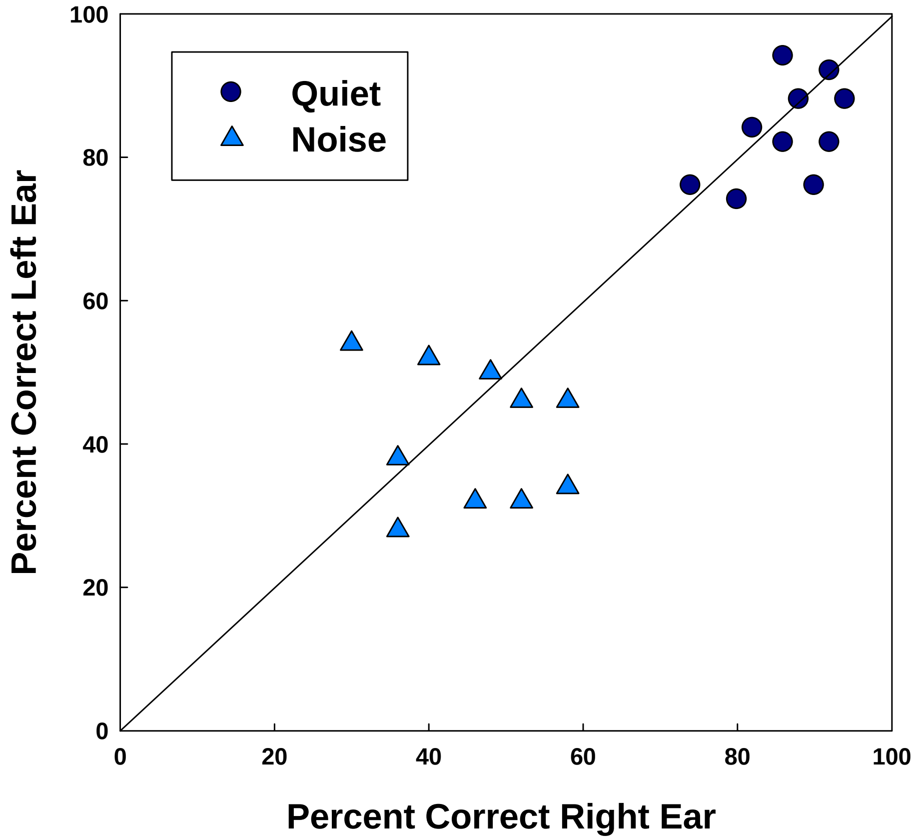

Figure 1. Individual data presented as a bivariate plot of percent correct recognition of the right ear (abcissa) and for the left ear (ordinate) in quiet and noise conditions.

the young adults in quiet is much smaller than the spread of the young adults in noise. The increased difficulty of the task not only reduced performance, it also produced more variability within the young adult subjects.

Before statistical analysis, the DWR percentage scores were transformed to a rationalized arcsine in order to eliminate the error associated with percentage data (Studebaker, 1985). In order to compare the young adult data between ears and across conditions (quiet vs. noise), the transformed data were subjected to a series of *t*-tests of means. Results revealed that mean performance of the RE in quiet was significantly better than RE performance in noise ($t_{18} = 10.89$; $p<.05$). Similarly, the LE in quiet performed significantly better than the LE in noise ($t_{18} = 10.70$; $p<.05$). This shows that the introduction of noise significantly reduced performance. Further, performance between ears (RE vs. LE) was not significantly different for either the quiet condition ($t_{18}=0.93$; $p>.05$) or the noise condition ($t_{18} = 1.03$; $p>.05$). Given the lack of significant differences in performance between ears within each experimental condition (quiet and noise), it follows that the mean right ear advantages in each group were also not significantly different ($t_{18} = -0.11$; $p>.05$).

In order to compare the young adult data (in noise) to that of the older adult data (i.e., Roup et al., 2006), the data were subjected to a one-way analysis of variance (ANOVA). As expected, no significant differences were observed in overall performance between young adults in noise and older adults ($F_{1,44} = 0.71$; $p>.05$). However, as can be seen in Figure 2, significant differences were observed between performance of the right ear and the left ear for the older adults ($t_{70} = 2.60$; $p < .05$), whereas there was no significant difference in performance between ears for the young adult subjects in the noise condition ($t_{18} = 1.03$; $p>.05$). When performance was equated between the two groups the differences between ears in the younger adults remained small and insignificant, whereas the older adults exhibited significant differences between ears.

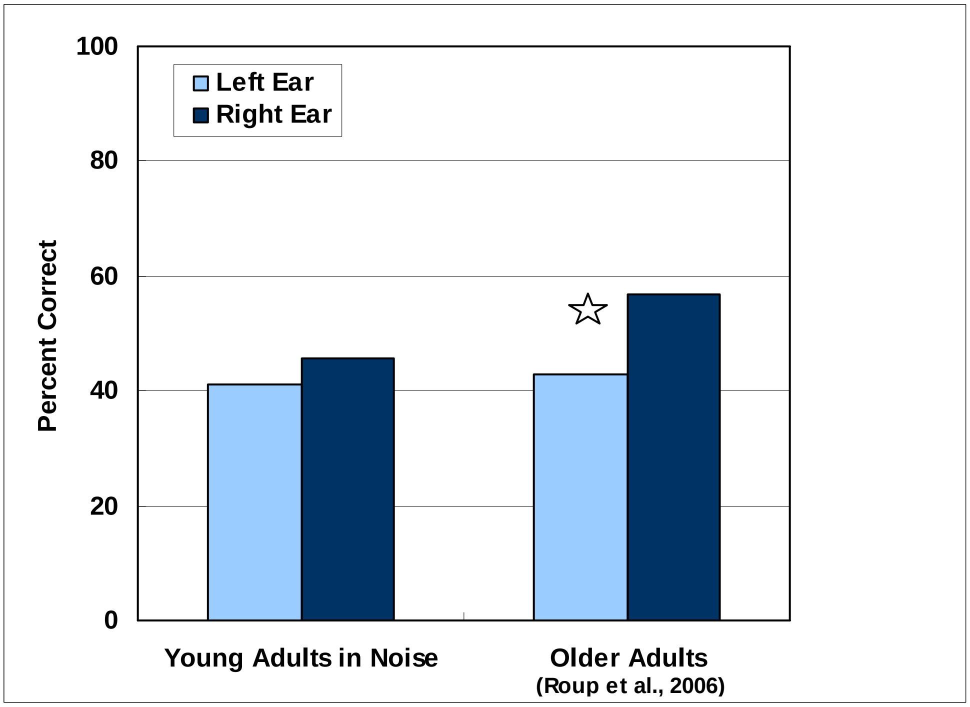

Figure 2. Mean dichotic word recognition performance (in % correct) for the right and left ears of young adults in noise and older adult data.
(☆ $p < .05$)

Chapter 4

DISCUSSION

The present study examined dichotic word recognition performance in quiet and noise conditions in a group of young adults with normal hearing. In the quiet condition, the mean right ear performance was 86.4% and the mean left ear performance was 83.6%., resulting in a mean right ear advantage of 2.8%. These results are similar to data collected from previous studies of young adults' performance on dichotic speech recognition tasks. Roup et. al. (2006) also studied dichotic word recognition performance of young adult listeners with normal hearing. In the free recall response condition, the mean right ear performance of young adults (ages 19-30) was 86.9%, left ear was 84.4%, and the right ear advantage was 2.5%. These results are similar to those of the present study. This was expected as the same monosyllabic word pairs were used as stimuli for both the Roup et.al. (2006) study and the present study, and both studies also used the free recall paradigm. However, even when different types of stimuli are used, the results among young adults remain fairly consistent. Strouse, Wilson, and Brush (2000) used the free recall response paradigm with dichotic digits stimuli. The mean right ear recognition performance ranged (depending on the number of digit pairs presented) from 93.8% to 99.8%, left ear from 90.3% to 99.4%, and the right ear advantage from 0.7% to 6.9%. While digits produce slightly better performance than monosyllabic words, young adults perform consistently well in dichotic speech recognition tasks and exhibit small right ear advantages.

Dichotic word recognition performance was also measured in a background of speech spectrum noise. The introduction of background noise was done in order to examine the effect reduced overall performance on the right ear advantage. Not surprisingly, when dichotic word recognition was measured in the presence of noise, performance of the young adults was significantly worse than in quiet. However, their right ear advantages remained small. Dirks (1964) also measured dichotic word recognition in a group of young adult listeners with normal hearing. The dichotic words were filtered, producing low overall performance across ears with a right ear advantage of 7%, similar to that of the present study. Despite the increased difficulty of the task via the introduction of noise or filtering, right ear advantages of young adults remain small, particularly when compared to the right ear advantages exhibited by older adults (e.g., 10-19%) (Strouse & Wilson, 1999; Strouse et al., 2000; Wilson & Jaffe, 1996).

After performance was reduced by the introduction of noise, the young adults' data was compared to the combined older adult data reported by Roup et al. (2006). The lack of significant difference in performance between the young adults in noise and the older adult data shows that the performance of the young adults was successfully reduced to equal that of the older adult data. DWR performance of the right ear was better than performance of the left ear for both young adult conditions (quiet and noise) and for the older adult data. However, significant differences between performance of the right and left ears were only present in the older adult data. One might argue that the significant differences in performance between ears among older adults are the effects of the sensorineural hearing loss. However, when performance of the young adults was reduced to equal the performance of older adults with hearing loss, the difference in performance between ears remained insignificant.

The lack of a significant difference in performance between ears of the young adults even in the presence of noise lends support to the idea that the exaggerated ear differences exhibited in older adults are a reflection of age-related deficits in auditory processing rather than the presence of peripheral hearing loss. As dichotic listening involves the communication between the right and left hemispheres, a deficit in auditory processing could clearly result in poor dichotic performance. The underlying cause of this suggested auditory processing deficit is an age-related degradation of the corpus callosum (Jerger et al., 1995). In dichotic listening, the stimuli presented to the left ear must travel contralaterally to the right hemisphere, and then cross to the left hemisphere via the corpus callosum. Energy is thought to be lost during this process, creating the right ear advantages seen in the majority of all dichotic testing. In the presence of a degraded corpus callosum, the left ear would be even more disadvantaged, possibly explaining the exaggerated left ear deficits found in the older adult data.

Clinical Implications and Future Research

The results of the present study suggest that an auditory processing deficit is present in these older adults, in addition to the hearing loss. Clinically, this information could possibly result in more successful rehabilitation efforts. Typically, older adults with age-related sensorineural hearing loss are fit with bilateral hearing aids. However, in the presence of the suggested deficit in auditory processing, a monaural fitting may be more beneficial. Carter, Noe, and Wilson (2001) studied 4 older adults who preferred monaural amplification. All 4 subjects exhibited large right ear advantages (i.e., left ear disadvantages) for dichotic digit recognition. Word recognition performance was then measured under bilateral amplification, monaural right ear amplification, and monaural left ear amplification. Monaural right ear amplification resulted in best performance, except in the presence of an FM. Therefore, as monaural right ear amplification generally resulted in best performance, the presence of a significant left ear deficit may suggest that a monaural hearing aid fitting would be more successful. In this manner, dichotic speech recognition has potential to aid in the diagnosis of auditory processing deficits, which in turn may result in more successful hearing aid fittings for older adult listeners.

As only 10 young adult subjects were tested, additional research will need to be conducted in order to further substantiate the proposal that the increased difficulty of the task (i.e., the hearing loss) is not the cause of the significant difference in performance between ears among older adults with hearing loss. Further research could also investigate the ear advantages found in older adults without hearing loss. This population may also exhibit significant left ear deficits. Although they do not exhibit age-related hearing loss, they may exhibit the significant ear difference due to the presence of an age-related deficit in auditory processing.

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APPENDIX A

Handedness Inventory

Please indicate your preferences in the use of hands in the following activities by checking the appropriate column.

Some of the activities require both hands. In these cases the part of the task, or object, for which hand preference is wanted is indicated in brackets.

Please try to answer all the questions, and only leave a blank if you have no experience at all of the object or task.

	LEFT	RIGHT
1. Writing		
2. Drawing		
3. Throwing		
4. Scissors		
5. Toothbrush		
6. Knife (without fork)		
7. Spoon		
8. Broom (upper hand)		
9. Striking Match (match)		
10. Opening Box (lid)		